EXHIBIT H

T-72

TDX CONSTRUCTION CORPORATION
Baruch College Field Office 137 East 25th Street, 6th Floor, New York, NY 10010
212 679 3031
212 679 3037 fax
www.tdxconstruction.com

August 28, 2003

Trataros Construction, Inc.
55 Lexington Avenue
New York, NY 10010

Attn: Gus Trataros

RE: Baruch College – Site "B"
Contract No. 16 (GC-2)
Terrazzo Flooring at Site 'B'

Gentlemen:

There have been deteriorating and hazardous conditions due to the deficiencies of the terrazzo flooring and underlayment installation at Baruch College Site 'B.' The flooring deficiencies, which have been evident for some time, present unsafe conditions for the high volume of foot traffic that walk through the building each day. These unsafe conditions had prompted a variety of testing and inspection agencies to perform independent tests on various locations throughout the entire terrazzo flooring area with Site 'B.' (See enclosed reports).

Based on the findings of the independent testing agency reports, its has been determined that the deficiencies in the terrazzo installation and underlayment are your responsibility.

You are therefore notified to remove and replace all materials installed throughout the building that are covered by the terrazzo flooring, including underlayments below the terrazzo flooring system. Prior to any action to be taken on Site 'B,' as stated in the contract documents, the replacement and corrective work must be resubmitted and approved.

Please contact this office to expedite the repair process and to coordinate the removal, repairs, and reinstallation of the terrazzo flooring system and underlayment.

Very truly yours,
TDX Construction Corporation

for Ray Leu

Ray Leu
Project Manager

JOG/

cc: Steve Boiko – Dormitory Authority, Michael Kolk – Dormitory Authority, Jay Goldstein – Dormitory Authority
Anil Raut – Dormitory Authority, Wayne Markowitz – Dormitory Authority, John Mueller - Dormitory Authority
Jim H. Jones – TDX, John McCullough – TDX, Jim R. Jones – TDX
Vincent Anastasi - Crocetti, TCI Bonding Co. – Travelers, Athena Curis – Trataros
File

terrazzo

THE NATIONAL TERRAZZO & MOSAIC ASSOCIATION, INC

THE NATIONAL TERRAZZO & MOSAIC ASS'N, INC.

RECEIVED
APR 29 2003
TDX CONSTRUCTION

April 28, 2003

Mr. Tom Spinthourakis
TDX Construction Corporation
345 Seventh Ave.
New York, NY 10001

To Whom It May Concern:

Herewith our On-Site Terrazzo Inspection Report by Mr. Wayne Grazzini of the Baruch College in New York, New York.

A refund of the remaining finances or billing of additional charges from the expenses of the inspector will be sent separately after reconciliation of the expenditures.

Please feel free to send copies of the inspection report to any party concerned.

Sincerely,

George D. Hardy

George D. Hardy
Executive Director

RECEIVED
MAY 0 2003
TDX CONS

(800) 323-9736 VA (540) 751-0930
Fax (540) 751-0935
201 North Maple Avenue
Suite 208
Purcellville, VA 20132

April 17, 2003

NTMA On-Site Inspection of Epoxy Terrazzo Installation at *Baruch College*

55 Lexington Avenue
New York, NY 10010

At the request of the NTMA (subsequent to request from TDX Construction Corporation) I flew to New York on Wednesday April 9, 2003 to view the above Terrazzo installation and meet with Mr. Tom Spinthourakis of TDX and others. Prior to my arrival in New York, Mr. Spinthourakis had forwarded to me copies of a "basic information package concerning the uplifting Terrazzo at Baruch College", i.e. specifications, Testwell Laboratory reports, MSDS, etc.

I arrived at the site approximately 11:30AM and did a very quick walk-thru of the street level prior to meeting with the following individuals at approximately 12:00 Noon.

THOSE IN ATTENDENCE:

Mr. Tom Spinthourakis w/ TDX
Mr. Daniel G. Kaufmann – Assistant Vice President / Campus Facilities and Operations – Baruch College
Mr. Peter Cavassa – Operations Coordinator Campus Facilities and Operations – Baruch College
Mr. Steve Wu – Project Manager Campus Facilities and Operations – Baruch College
Mr. Thomas Schmidt – Chief Engineer Buildings and Grounds – Baruch College
Mr. Ken Sanden – Project Manager The City University of New York (CUNY)
Mr. Richard Gardner – Terrazzo Supervisor – GM Crocetti, Inc.
Mr. Gary Markus – GM Crocetti, Inc.

THE PROBLEM:

The NTMA was asked to address the "Request for On-Site Inspection" provided to the NTMA dated 3/14/03 which stated "*The Epoxy membrane is separating from the substrate, specifically at the perimeter zinc strips. The center of the 2'x4' Terrazzo panels seem to be retaining their full adhesion. In addition there seems to be something causing an epoxy shrinkage giving the surface an alligator/bumpy finish!*"

Terrazzo Site Inspection Report

Baruch College

New York, New York

Visual On-Site Inspection of Terrazzo Work for the Baruch College

April 9, 2003
by
Mr. Wayne Grazzini,
of WT Grazzini Terrazzo & Tile, Inc.
for the
The National Terrazzo & Mosaic Association, Inc.
201 North Maple Avenue
Purcellville, Virginia 20132

PRE INSPECTION MEETING:

At the beginning of this meeting I explained my reasons for being there on that day and the NTMA's role in the Terrazzo industry, i.e. dissemination of information, education, etc. and explained that I was there to determine adherence to NTMA Guidelines. Further, I explained my qualifications as an inspector.

At this time I allowed others to present the facts as they saw them, viewed numerous samples removed from the floor, followed by an interview (in front of all present) with GM Crocetti, Inc. to provide me with a step by step dissemination of their Terrazzo installation methods.

INSPECTION:

As a group starting at the 14th floor, we walked each floor down to the Street level and several floors below street level. For the most part the adhesion problem appeared to be most pronounced on floors 13 down through the street level. The alligator/bumpy finish was much less pronounced on these floors (but present to some degree) with the exception of the 1st & 2nd level elevator lobbies, which appeared to have the most alligator/bumpy finish present in the lighter colored Terrazzo directly in front of the elevator cabs.

EVALUATION:

The Terrazzo finish is completed in a manner which would generally meet NTMA Guidelines. The "alligator/bumpy" finish, as agreed by all parties, has appeared post job completion.
The Terrazzo exhibits density of aggregate and matrix which would generally meet NTMA Guidelines.
The Terrazzo appears to be fully bonded to the membrane in all visible cases.
The membrane is not fully bonded to the underlayment in many instances.
The underlayment does not appear to by of a type that would meet NTMA requirements.
The underlayment has flaked/cracked in many instances, and exhibits immediate deterioration in the presence of moisture.

OPINION:

The failure of the bond between the membrane and the underlayment is caused by the use of an underlayment which is deteriorating, and is of a type that I believe would not meet NTMA Guidelines. The failure may have been further aggravated by deflection caused by loading of the "Post Tension" concrete, and additional areas of loose floor may be the result of the use of a concrete/curing hardener which was not completely removed from

the concrete prior to membrane installation (in fact the NTMA recommends that where epoxy Terrazzo is to be installed "curing compounds of any type are not to be used"). The "alligator/bumpy" finish seems to appear more in areas which we would assume get more maintenance, and the maintenance materials we were given MSDS's for and viewed in the storage areas contain Diethylene glycol methyl ether, which is a solvent and could cause deterioration of the Terrazzo finish. In fact, I observed one floor area where there were visible indentation lines of a 1 gallon bucket present in the Terrazzo floor.

RECOMMENDATIONS:

Remove the existing membrane and Terrazzo where it has disbonded and adjacent questionable areas.
Remove the existing non-conforming underlayment.
Install new underlayment meeting NTMA Guidelines.
Install new membrane, and Terrazzo surfaces.
Further research and analysis should be given to the maintenance and maintenance items being used/applied to these Terrazzo floors. Once a determination has been made for the proper maintenance materials and procedures, the areas of "alligator/bumpy" finish should be fine ground and/or screened to produce the original finish, to be turned over to the owner with recommendations for its future maintenance.

The inspection concluded at approximately 3:30PM.

Wayne T. Grazzini
President
WT Grazzini Terrazzo & Tile, Inc.
for the National Terrazzo & Mosaic Association, Inc.

TESTWELL LABORATORIES, INC.
CORPORATE HEADQUARTERS: 47 HUDSON STREET, OSSINING, N.Y. 10562
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PRELIMINARY SITE INVESTIGATION REPORT

Client:	TDX Construction Corp.	**Lab #:**	NBX-004AA
Project:	Baruch College - Site B	**Report #:**	ML-01/NBX-004
Address:	55 Lexington Avenue New York, New York	**Field Visit Date:**	03/04/03
		Report Date:	03/05/03
Construction Type:	Terrazzo flooring system on concrete slab	**Petrographer:**	J. Walsh
		Page 1 of 10	

1. INTRODUCTION

At the request of Tom Spinthourakis of TDX Construction Corporation, a site visit was made at Baruch College, New Campus Site B at 25th Street and Lexington Avenue, New York on March 4, 2003. The purpose of the visit was to investigate a debonding condition evident in an epoxy-based, cast in place terrazzo flooring system. TDX Construction had previously removed seven probes throughout the building by sawcutting debonded portions of the system past the failed sections and removing solid samples. The probes were carefully covered with pressboard and sealed with duct tape. Probes were identified by TDX Construction according to floor level (B1, 1G, 1N, 2W, 2E, 7, and 12). Probe locations are filed with TDX Construction. The samples were labeled and stored in the onsite Facilities Office in an organized manner.

The site visit included the following components:

1) A 2.5 hour walk-through of the probe locations where all probes were exposed and studied. The immediate vicinity of each location was also examined in a cursory manner to assess the magnitude of the condition.
2) A briefing with TDX project management to discuss preliminary findings and possible analyses.
3) A perusal with Tom Spinthourakis of relevant job specifications and materials specification sheets.
4) A subsampling of six of the seven probe locations to collect representatives of all conditions observed in the field. Subsampling was agreed to between the author and Tom Spinthourakis.
5) Identification of four coring locations for future sampling. The samples will be held for petrographic analysis if such analysis is requested by TDX Construction.

2. PLACEMENT HISTORY

According to Tom Spinthourakis, all construction at the site is relatively recent. The concrete slabs on which the terrazzo system was placed were cured in excess of 28 days before the flooring was installed. The terrazzo system was installed approximately one year ago under closed construction conditions with climate control already in place. The substrate was scarified or treated with one or more layers of self-leveling flooring (Conflow by Conspec) when required. No other pretreatments were clearly recalled. The substrate was coated by a roll-on epoxy membrane (FlexGuard by TEC). A gridwork of adhesive was placed on which zinc strips were adhered. The terrazzo system (Tuff-Lite 5 by TEC) was field mixed and placed. After curing of the epoxy matrix, the terrazzo was ground and polished using diamond pad. The final finish was described as smooth with no small-scale imperfections. Some typical larger scale undulations were noted. The debonding condition was observed soon after and was defined by a curling of the terrazzo segments at the zinc strips.

3. FIELD OBSERVATIONS

The following observations were made by the author during the jobsite walk-through:

1) The placement history is suggested by observed field relationships. A lightweight slab on deck was placed. A surface consistent with a trowel finish is detected (i.e.; a smooth surface containing all cream and no raised fine aggregate). In some locations (1G and 1N) a deep scarification of the hardened slab was performed. In others (2E), some fine scouring is evident. In other locations (B1, 2W, 7, and 12) one or more layers of self-leveling compound were placed over the structural slab. A thin layer of gray epoxy membrane was placed. Zinc strip adhesive was placed before the epoxy membrane solidified. This is indicated by the indentation of the membrane by the adhesive (most clearly detected at probes 2E and 12). The zinc strips were embedded while the adhesive was uncured (also indicated by indentation). It would appear that the membrane, adhesive, and strips were all installed in quick succession as a single procedure as no other disruption of the membrane is detected. The terrazzo system was placed after all other components were hardened (not necessarily cured) and well compacted against the zinc strips. The hardened terrazzo system was ground and polished.
2) Most terrazzo segments are 2 x 4 feet in plan separated by zinc strips. The pattern varies in more open areas.
3) All debondings may be described as convex curlings of individual terrazzo segments. The greatest separation and deflection occurs at corners. Central edges are usually well adhered and segment centers are always adhered. No complete debondings of entire terrazzo segments are observed (see also note 8 below).
4) Certain corridors and areas display greater failure than others. In some places, the debonding condition is not apparent. Some degree of failure is observed at every floor level examined.
5) No obvious structural pattern of debonding is evident. That is to say that the failure does not tend to occur in the vicinity of doorways or in the center of a corridor for example. The occurrences are essentially random.
6) At each probe, the failure occurs between the epoxy membrane and the substrate. The debonding occurred cleanly without pulling out any portion of the substrate and rarely leaving any residue of the membrane behind. This condition exists whether the substrate is concrete slab or self-leveling flooring. It is also notable that no residue of the epoxy membrane is found within any negative relief areas of the substrate. Even where the

substrate is deeply scarified (1G and 1N), no relict of the epoxy membrane remains in the grooves.

7) Each of the recovered samples display some residual material at the lower surface of the epoxy membrane. Nowhere is the lower surface of the epoxy found to be "fresh".

8) Probe 2W exposes a section centered on a corner of four terrazzo segments. The original debonding (as opposed to that created by the sample removal) is clearly defined as a rounded cross. This indicates a regular ovate pattern of failure.

9) Some salt deposits are detected along the exposed substrate and these are always coincident with the zinc strip locations. These deposits clearly post-date placement and are probably related to the drying of cleaning solutions after separation of the terrazzo with the zinc strips occurred and fluid access to the substrate was permitted.

10) No other horizontal failures are noted in the terrazzo system. The zinc strip adhesive is well adhered to the epoxy membrane as well as the L-shaped zinc strips. Horizontal contacts between the terrazzo system and the zinc strips are all intact. No failures are detected between the epoxy membrane and the terrazzo system.

11) Some indication of failure between the slab and self-leveling flooring bond is noted. This is evidenced by clean separations at probe locations 7 and 12. Probe B-1 exposes a four corner contact. Sounding of the substrate revealed a debonding of the Conflow only below one corner of the four terrazzo segments. Samples of the debonded Conflow were recovered freshly from the substrate.

12) No significant vertically oriented fractures are detected in the main body of the terrazzo. Only one location was identified near the 25th Street entrance on the ground floor. The crack is perpendicular to the construction and was suggested by Tom Spinthourakis to be related to an underlying slab crack. The form of the crack is consistent with that interpretation. Other finer scale vertical cracking is rare and is associated with the "alligator texture" discussed below.

13) Other vertical cracking is strictly related to the clean separation of the terrazzo from the zinc strips. This is not considered a failure as the zinc grid is likely designed as a control joint system. Separations are detected even where debonding is not present. The separations are of hairline thickness unless curling of the terrazzo has occurred. It is noted that separation occurs on one side of the zinc strip. In some cases, the separation switches sides with a small overlap. This is consistent with horizontally oriented tensile stress release from separations propagating on either side of the strip. No "double-sided" separations are detected. The separations propagate vertically through the lower epoxy membrane.

14) A possibly unrelated condition is informally described as "alligator texture" and was pointed out by Tom Spinthourakis. The texture is observed more or less at all locations and is defined by a differential surface relief between the aggregate (in high relief) and the epoxy matrix (in low relief). The texture usually occurs at terrazzo segment edges but often juts into the main body of the terrazzo in a curving manner. At first, it was thought there might be a correlation between lower abundances of aggregate and the alligator texture but this correlation was not borne out by further site examination. In fact, it is sometimes observed where there is a locally high concentration of aggregate grains. According to TDX, the texture did not exist immediately following the finishing operation.

4. PRELIMINARY CONCLUSIONS

The scale of the failure is confined to within terrazzo segments and exhibits no coherent relationship to underlying structural units. Therefore, it is believed that the cause of the problem is limited to the flooring application and not larger scale movements or failures of the underlying structural slab. The morphology of the failure tends to be defined by a convex curling and an ovate pattern of debonding. This is consistent with deformation related to material shrinkage and this shrinkage is believed to be the primary *stress* leading to the debonding. However, shrinkage is supposed to be accommodated by failure along the zinc joints and it should be stressed that no suggestion is being made here that shrinkage was *necessarily* excessive. The debonding occurs strictly between the epoxy membrane and the substrate regardless of whether the substrate is lightweight concrete or self-leveling compound. Furthermore, the debonding is usually complete with no residual epoxy membrane adherent to the substrate even where scarified. Clearly, the epoxy-substrate bond is the weakest in the system. This weak bond appears to be exploited by the natural material shrinkage.

There appears to be some evidence of residues below the epoxy membrane and this is an area for further investigation. Incomplete cleaning of the substrate may be responsible for a weak epoxy bond. This seems likely particularly where the concrete slab is scarified and the membrane has not even adhered to the rough grooves of the preparation. In terms of materials, there does not appear to be any deviations from the manufacturer's recommendations. It may be more difficult to determine whether or not a curing agent had been applied to the concrete.

The "alligator texture" may be related to shrinkage as the epoxy matrix is in lower relief relative to the aggregate. However, the distribution pattern is not very ordered and it may be difficult to relate this texture to shrinkage of the product.

5. SUGGESTIONS FOR FURTHER ANALYSES

A) Most laboratory analyses will not be able to assess the manufacturer's claims on material behavior. Empirical tests on fresh material would need to be performed. Results of such tests should be sought from the manufacturer as a first step.

B) A low power microscopic analysis of the field samples should be performed to investigate the nature of the lower epoxy surface. Some indications of contaminants or residues may be identified in such an analysis. Other bonding surfaces and microcracking may also be investigated.

C) Some "oily" looking residues were reported by Tom Spinthourakis and at least some suggestion of this is evident in the field samples as received. FTIR analysis can qualitatively identify the presence of organic functional groups and these can be compared to those reported in the MSDS sheets of the epoxy membrane. Any functional groups not belonging to the epoxy may be considered a contaminant.

D) A full petrographic analysis of fresh core samples may be desirable. Samples will be milled to 30 µm thickness in an intact condition and analysed under high power polarized transmitted light. The original undisturbed bonds can be assessed and any dust layers may be identified. Microscopic bonding of other components of the terrazzo system will be addressed as well as the nature and quality of the concrete substrate.

TESTWELL LABORATORIES, INC.

John J. Walsh
Petrographer

Kaspal R. Thumma. Eng. Sc. D. P.E.
Vice President/Laboratory Director
Krt/jjw

Samples will be discarded after three months unless otherwise instructed. This report is the confidential property of the client and any unauthorized reproduction is strictly prohibited. The interpretations and conclusions presented in this report are based on the samples provided.

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PHONE: (914) 762 - 9000 www.testwelllabs.com FAX: (914) 762 - 9638

PETROGRAPHIC INVESTIGATION OF A DEBONDED TERRAZZO FLOORING SYSTEM

Client:	TDX Construction Corp.	**Lab #:**	NBX-004AA
Project:	Baruch College - Site B	**Report #:**	ML-04/NBX-004
Address:	55 Lexington Avenue New York, New York	**Date Drilled:**	03/21/03
		Report Date:	04/15/03
Construction Type:	Terrazzo flooring system on concrete slab		
Drilled by:	TLI	**Petrographer:**	J. Walsh
Delivered by:	TLI	**Page 1 of 35**	

PETROGRAPHIC INVESTIGATION OF TERRAZZO FLOORING SYSTEM CORES, BARUCH COLLEGE - SITE B, NEW YORK, NEW YORK

Report to

TDX CONSTRUCTION CORPORATION
TLI Lab #: NBX-004AA; Report #: ML-04/NBX-004
April 15, 2003

1. INTRODUCTION

This report presents the findings of a petrographic examination performed on three core samples recovered by Testwell Laboratories' field personnel on March 21, 2003 at Baruch College - Site B at 55 Lexington Avenue, New York. Coring locations were chosen by Tom Spinthourakis of TDX Construction Corporation based on consultations with the author. The core samples are intended to complement previous samples collected by TDX Construction and provided to Testwell Laboratories as well as observations made during a jobsite investigation performed on March 4, 2003. Related reports referenced here include a site investigation report (TLI Lab #: NBX-004AA; Report #: ML-01/NBX-004) and an FTIR analysis of possible residues (TLI Lab #: NBX-004AA; Report #: ML-02/NBX-004).

The purpose of the examination is to investigate a debonding condition evident in an epoxy-based, cast-in-place terrazzo flooring system placed throughout the 55 Lexington Avenue location. In addition, surface defects informally identified by the client as "alligator texture" are also investigated. According to the client, the terrazzo system was installed approximately one year ago under closed construction conditions with climate control already in place. The system is placed directly over concrete slab-on-deck in some locations and over a self-leveling flooring system in other locations. The self-leveling material is identified by the client as "Conflow" by Conspec and is referred to as Conflow hereafter. No obvious defects (short of some typical larger scale surface undulations) were observed immediately following placement. However, debonding of the terrazzo was detected relatively soon after placement. No information about the first appearance of the "alligator texture" was communicated.

Data compiled in this report include information collected from the field, from debonded samples collected by TDX Construction, and from core samples recovered by Testwell Laboratories. The field locations include terrazzo surfaces observed at basement, ground, second, seventh, and twelfth floor levels as well as seven debonded probes exposed by TDX Construction Corporation. Probes were identified by TDX Construction according to floor level (B1, 1G, 1N, 2W, 2E, 7, and 12). Samples collected from these probes are also referred to in this report with the exception of probe 7 which was determined to be sufficiently similar to probe 12 during the subsampling. Core samples were chosen to encompass the range of substrate types as well as sampling the above-mentioned "alligator texture". Locations were chosen to intersect fully bonded sections of the terrazzo system in order to avoid any contamination later introduced by cleaning solutions or residues introduced following sampling. The core samples were recovered in good condition and were immediately transported to the laboratory and properly secured. One exception is core #3 which developed a horizontal separation between two lifts of Conflow during the coring operation. Core #1 was sampled at ground level over concrete in an area not exhibiting a debonding condition. Core #2 was sampled at the second floor where the terrazzo overlies Conflow and exhibits "alligator texture". Core #3 was sampled at the second floor where the terrazzo overlies Conflow and debondings are noted locally.

2. SUMMARY STATEMENT

With respect to the "alligator texture", the deformation is clearly associated with tensile cracks in core #2 and possibly related to settlement of some fine aggregate material within the terrazzo layer. However, it is felt that the macroscopic distribution pattern is more consistent with a feature produced during floor maintenance rather than a problem within the material itself. No evidence is provided that might suggest the nature of any solutions that could result in such a texture. However, acidic solutions are ruled out and the epoxy binder would likely be more sensitive to organic-based solutions. With the exception of this surface texture, no other obvious defects are found in the composite terrazzo flooring system.

The debondings do not correlate with the "alligator texture" and it is believed that these represent an unrelated failure. The weakest bond in the entire flooring system appears to be the upper surfaces of Conflow lifts. These are characterized by a soft laitance of hydrates and in some cases a fine efflorescence. The laitance is related to an extreme segregation of Conflow components that is interpreted to have been caused by excess water added to the mixture. The weakness in the Conflow is determined to be the location of many of the debonding failures including directly below epoxy membrane, between Conflow lifts, and between Conflow and concrete substrate.

Another potential cause for failure may reside in the concrete substrate. There is some evidence to suggest that some debondings may be associated with a material tentatively identified as a concrete sealant. It is not known to what extent such a sealant would be incompatible with either the epoxy membrane or the Conflow self-leveling material. There is also evidence in core #1 indicating an incipient delamination caused by overworking of the air-entrained concrete surface. It is not known whether a similar delamination exists below the scarified concrete at probes 1G and 1N where debondings have been detected.

A more detailed discussion of the findings of this examination may be found in the "Conclusions" section of this report.

3. METHOD OF EXAMINATION

The following petrographic examination was conducted in accordance with the standard practices contained in *ASTM C856: Standard Practice for the Petrographic Examination of Hardened Concrete*. Data collection is performed by a degreed geologist who by nature of his/her education is qualified to operate the analytical equipment employed. Analysis and interpretation of the data is performed in a collaboration between the supervising petrographer and professional engineer who by nature of their education and experience in the field of construction materials and technology are qualified to offer interpretative statements based on the dataset.

Steps followed during petrographic examination include:

(a) Thorough visual examination of the core (or other sample type) prior to destructive sample preparation methods.

(b) Examination of freshly fractured sections of the core (or other sample type) under a reflected-light stereoscopic microscope.

(c) Examination of a polished section of the core (or other sample type) under a reflected-light stereoscopic microscope.

(d) Treatment of the polished section with phenolphthalein indicator solution to determine the depth and distribution of carbonation if necessary.

(e) Examination of ground materials in various oil immersion grain mounts under a polarized light microscope.

(f) Examination of petrographic thin sections under reflected light and polarized light microscopes. Thin sections are prepared so as to maximize the obtainable data as dictated by the scope of the examination. In most cases these will include large area thin sections with a blue-dyed, ultra-low viscosity epoxy impregnation to highlight cracks, voids and capillary pores.

(g) Treatment of additional polished, sawn, or fractured sections with uranyl acetate solution and observation under 254 nm ultraviolet radiation to test for the presence of alkali-silica reaction gels (if suspected).

(h) Examination of stained thin sections or additional stained polished sections to test for the presence of potentially reactive carbonate aggregates (if suspected).

(i) Utilization of any other analytical means deemed necessary to satisfy the scope of the examination.

(j) Distillation and interpretation of the collected dataset by a qualified analyst.

(k) Photographic documentation of important aspects of the concrete system.

4. FIELD OBSERVATION AND INTERPRETATION SUMMARY

The following observations are described in more detail in the preliminary site investigation report (TLI Lab #: NBX-004AA; Report #: ML-01). A distilled discussion is provided here as supportive field information for the conclusions drawn.

1) The field placement was interpreted based on observed relationships. A trowel-finished concrete slab on deck was placed. In some locations a deep scarification of the hardened slab was performed. In other locations, one or more lifts of self-leveling compound were placed over the structural slab. A thin layer of gray epoxy membrane was placed. Zinc strip adhesive was placed before the epoxy membrane solidified. The zinc strips were embedded while the adhesive was uncured (generally in a 2' by 4' plan). The terrazzo system was placed after all other components were hardened and well compacted against the zinc strips. The hardened terrazzo system was ground and polished.
2) All debondings may be described as concave curlings of individual terrazzo segments with greatest deflection at corners forming an ovate pattern of failure.
3) The large-scale pattern of failure is essentially random with no apparent structural control. Debondings were witnessed at the basement level and 1st, 2nd, 7th and 12th floors.
4) All observed terrazzo debondings occur below the epoxy membrane. There is usually some "residue" present below the membrane. Rarely is there a residue of the epoxy membrane on the substrate.
5) All contacts within the flooring system (i.e., terrazzo, epoxy membrane, zinc strips, and adhesive) are found to be intact. Clean vertical debonding between the terrazzo and zinc strips are consistent with designed control joints. No significant vertically oriented fractures are detected in the main body of the terrazzo.
6) Some indication of failure between the slab and self-leveling flooring bond is noted as well as failure between lifts of Conflow.
7) A condition informally described as "alligator texture" is observed more or less at all locations and is defined by a differential surface relief between the aggregate (in high relief) and the epoxy matrix (in low relief). According to TDX, the texture did not exist immediately following the finishing operation.

5. BRIEF DESCRIPTION OF FIELD SAMPLES COLLECTED BY TDX CONSTRUCTION

On March 4th, 2003, Testwell Laboratories collected six samples from the seven probes sampled by TDX Construction at the jobsite. While thin sections were not prepared for these materials, all samples were studied by reflected light microscopy both in "as-received" condition as well as in polished cross section. Some relevant information is included here pertaining to the debonded sides of these samples.

Samples 1G and 1N

Both samples represent terrazzo over scarified concrete. The debonding occurs between the epoxy membrane and the underlying concrete substrate. Where the epoxy overlies the scarred portions of the concrete, there is a residue of concrete fragments adherent to the epoxy membrane. The fragments do not represent concrete dust or uncleaned portions of the slab but rather larger scale fragments pulled up from the substrate. Between the scars over trowel-finished concrete, a "sticky" translucent residue is observed. The residue was sampled and compared to the epoxy membrane

using FTIR-ATR (TLI Lab #: NBX-004AA; Report #: ML-02). Results indicate the presence of styrene acrylate in the residue. This compound is a common ingredient in concrete sealants.

Samples B1 and 2E
Both samples represent terrazzo over Conflow. The debonding occurs between the epoxy membrane and the underlying self-leveling substrate. However, little residue of the self-leveling material is present below the epoxy membrane. Instead, a "sticky" translucent residue similar to that observed on the ground floor samples is detected.

Sample 2W
The sample represents terrazzo over Conflow. The debonding occurs between the epoxy membrane and the underlying self-leveling substrate. The debonding occurs cleanly between the two layers.

Sample 12
The sample represents terrazzo over two lifts of Conflow. Debonding occurs between epoxy membrane and Conflow, between the two lifts of Conflow, and between Conflow and the underlying concrete substrate. The upper lift of Conflow exhibits segregation of aggregate and the lower lift exhibits no aggregate at all. In both lifts, there appears to be a smooth gradation of color and material coarseness up through the lift. The debonding surfaces superficially appear to be composed of a primer layer. However, evidence from core #2 and #3 (see below) suggest that this might actually represent a soft laitance through which the debonding occurs. No thin sections were made for this sample.

6. CORE LAYER DIMENSIONS

Core #1 (Ground floor - northeast corridor)
Terrazzo layer - 3/8" thickness (L-shaped zinc strips are included with 1/8" verticals and 1/32" horizontals. Adhesive thickness is approximately 1/32").
Epoxy membrane - Approximately 1/32" thickness
Normal weight concrete - 3" recovered (snapped off intentionally to avoid underlying utilities)

Core #2 (Second floor atrium - corridor 2-200)
Terrazzo layer - 11/32" thickness
Epoxy membrane - Approximately 1/32" thickness
Conflow layer - 7/8" thickness
  1st lift - 9/32"
  2nd lift - 5/32"
  3rd lift - 7/16"
Lightweight concrete - 2-1/4" recovered (snapped off intentionally to avoid underlying utilities)

Core #3 (Basement level - corridor B1-125)
Terrazzo layer - 3/8" thickness
Epoxy membrane - Approximately 1/32" thickness
Conflow layer - 7/16" thickness
  1st lift - 7/32"
  2nd lift - 7/32"
Normal weight concrete - 1-7/8" recovered (snapped off intentionally to avoid underlying utilities)

7. PETROGRAPHIC DATA

Terrazzo layers

Petrographically, the terrazzo compound is characterized by a light gray organic binder containing natural crushed stone aggregate. The aggregate is composed of limestone, calc-silicate, and mollusk shell fragments with a nominal top size of 3/16". No potentially reactive material is detected within the aggregate.

The zinc strip and adhesive contained within core #1 are well bonded to the terrazzo material. No evidence of corrosion of the zinc strips is detected. The contact between terrazzo and underlying epoxy membrane is found to be tight in all three cores. These microscopic observations are consistent with observations of the earlier collected samples as well as relationships observed in the field.

Core #2 was sampled to be representative of the "alligator texture". Some much finer scale texture was also detected in core #1. In microscopic cross section the texture is characterized by downward warping of the epoxy binder between aggregate grains that stand in higher relief. At the microscopic scale there is a clear association of microcracking related to areas of deformation of the binder. The cracks are tensile and in most cases originate at interfaces between the aggregate and the epoxy binder. Propagation of the crack tips into the epoxy tend to follow a roughly vertical orientation. Microcracks tend to be more abundant near the terrazzo surface but are also observed throughout the thickness of the layer. It is also noted in core #2 that much of the finer carbonate aggregate has settled to the bottom of the layer. Core #1 displays some similar microcracking off to one side of the embedded zinc strip and some minor deformation of the binder surface is also detected. The deformation is not visible at the macroscopic scale. A minor settling of fine aggregate is also detected here but to a much lesser degree than in core #2.

Epoxy membrane layers

Little information about the epoxy membrane is determined by petrographic methods. The membrane is simply identified as an organic material. Chemical information about the membrane is provided by FTIR-ATR analysis (TLI Lab #: NBX-004AA; Report #: ML-02/NBX-004). Nothing uncharacteristic of an epoxy system is detected in the measured infrared absorbance spectrum.

In microscopic sections of the recovered core samples, the epoxy membrane is observed to be tightly adhered to both the overlying terrazzo system as well as the underlying substrate. Delaminations are detected in the cores but these are typically found just below the membrane/substrate contact. This is consistent with observations of samples collected by TDX Construction where there is usually some residue of substrate materials adhered to the membrane layer. The exception to this is sample 2W which exhibits a clean separation between the epoxy and the upper lift of Conflow.

Conflow layers

The self-leveling material is composed of siliceous natural sand fine aggregate, Portland cement hydrates and residues, small amounts of flyash and very fine grained, low birefringent, low index crystalline material. The very fine grained material may be gypsum based on optical properties. The material is identified by the client as Conflow by Conspec.

In most Conflow lifts there is a clear textural gradation. The gradation is best defined by size segregation of fine aggregate with an absence of aggregate at the upper portions of the lift. There is also a more subtle "fining upward" of the various hydrates and residual cementitious materials. In some lifts (within sample 12 for example) there is a complete absence of aggregate. Some clue to this structure is evident in the lower lift of core #3 where a layer of segregated sand tapers out to zero thickness midway between the core.

In all cases, the upper portions of each lift are composed of unsanded, soft, matrix dominated material. In sample 12 , this has the outward appearance of some type of primer coat. However, similar material in core #2 and #3 is observed in thin section to be a smooth gradation of segregated material. In core #3, the uppermost surface of each lift comprises an ultra-thin crust or efflorescence of (possibly) calcium hydroxide overlain by calcium carbonate. The crystals composing the crust are found in a somewhat porous open network at the microscale. Of the two recovered cores, core #3 displays the softest upper layers and consequently debonded between lifts during the coring operation. Core #2 displays better bonding between Conflow lifts.

Also noted were vertical shrinkage cracks penetrating Conflow layers in core #3 and sample 12. Between shrinkage cracks in sample 12, there is a fine plumose structure along the debonded surface. The structure is defined by thin, finely spaced, parallel ridges. These usually truncate against shrinkage cracks and vary in orientation across shrinkage cracks.

Concrete layers

In all three recovered core samples, a millimeter-scale darkening of the upper surface of the concrete is detected that is not related to any material differences such as locally lower water-cement ratios or an increase in residual Portland cement particles. While concrete sealants cannot be positively identified through petrographic techniques, the diffuse darkening is typical of concrete surfaces that are treated with penetrative sealants or curing compounds. A chemical signature consistent with concrete sealant is detected by FTIR-ATR analysis in the ground floor samples (TLI Lab #: NBX-004AA; Report #: ML-02/NBX-004).

The normal weight structural concrete in core #1 is air-entrained. However, an incipient delamination is observed approximately two to three millimeters below the concrete surface and no air-entrainment is present above the failure. No other physical deterioration is observed within the three examined core samples. In all cases, the concrete substrate comprises typical slab on deck design with moderate water-cement ratios and adequate hydration characteristics. Surface carbonation is minimal and no deleterious substances are detected. No other significant concrete information is provided by the samples recovered earlier by TDX Construction Corporation.

8. CONCLUSIONS

"Alligator Texture"

The cause of the "alligator texture" is not positively identified in this study. Evidence seems to be contradictory. In the single core representative of the condition recovered for petrographic examination there would seem to be some indication of an inherent material failure. The deformation of the surface correlates strongly with tensile cracks intersecting the surface of the terrazzo. However, most "alligatoring" observed in the field is not accompanied by surface penetrating cracks. No information is available to indicate whether or not all the "alligatoring" is related to subsurface cracking. There could be a correlation between the occurrence of "alligatoring" and settlement of some fine aggregate within the terrazzo layer.

It is felt that the macroscopic distribution of the texture is more telling with respect to the responsible process. Most "alligatoring" occurs at terrazzo field edges adjacent to zinc strips. In other cases, the texture swirls out into the terrazzo field in circular arcs. Finally, there does not appear to be a coherent pattern of areas displaying the texture. If the failure derived from an inherent property of the material, it would be expected that "alligatoring" would consistently appear throughout zones poured from a single mix. The pattern itself is more suggestive of something created by a rotary device such as a buffing machine and it is possible that the maintenance of the flooring may be responsible.

In the vast majority of cases, the texture is characterized by a deformation of the binder with the aggregate remaining unaffected. This rules out the influence of acidic solutions as the aggregate is acid soluble and would be etched by something like a muriatic solution. As the binder is 100% epoxy based it would be expected that an organic solution would have more effect. Questions related to compatibility of cleaning solutions are better addressed to the terrazzo manufacturer as they would be more familiar with the sensitivity to various chemicals of their proprietary formulation.

Finally, it is notable that there is no correlation between the occurrence of "alligator texture" and areas where debonding is experienced. There is no evidence to suggest that these processes are in any way related.

Terrazzo system

The scope of this study does not include an analysis of the aesthetic properties or finishing tolerances of the terrazzo placement. However, with the exception of observations described above, no obvious deficiencies are noted within the terrazzo system at any of the probe locations or core samples. The terrazzo system comprises the epoxy binder and aggregate mixture, epoxy membrane, zinc strips, and zinc adhesive. With the exception of designed vertical separation between the terrazzo and the zinc strips, no debonding failures are noted within the system. It is understood that questions have been raised with respect to corrosion or other chemical deterioration of the zinc strips. No such corrosion is detected in this examination.

At the time of the initial field investigation the fact that the material comprising the terrazzo binder is a 100% solids epoxy was neglected. It is agreed that such a formulation should be free from shrinkage. However, some questions remain regarding the observed curling of the terrazzo segments and we maintain that this deformation is at least consistent with some component of

debondings are occurring within the laitance described above due to the reduced strength of the segregated material.

Overall, it appears that the Conflow laitance defines the weakest bond within the flooring system particularly when the laitance is on the order of a millimeter or so. When an efflorescence is present above this laitance, the weakness may be present at the uppermost surface of the lift. It is likely that a large percentage of the service failures are related to weaknesses present in the self-leveling treatment. These weaknesses are interpreted to be the result of an excess of water added to the mixture during placement. However, samples B1 and 2E may contain an additional weakness. In particular, probe location B1 exhibited a clear debonding surface within the laitance still present after sampling but the uppermost debonding occurred just below the epoxy membrane which had a "sticky" residue adhered to the failed surface. This residue is superficially similar to that detected along the ground floor probes. This residue is discussed below.

Concrete

The debonding condition is widespread throughout the building and the total sampling exposure is relatively small. Without more confident information it is difficult to say that debonding tends not to occur between terrazzo and concrete substrate. In fact, two of the seven original probes expose failure between scarified concrete and epoxy membrane.

One possibility considered involves residues observed beneath the epoxy membrane at locations 1G and 1N. The residue was analyzed by FTIR-ATR (TLI Lab #: NBX-004AA; Report #: ML-02) and styrene acrylate was detected. This compound is a common ingredient in concrete sealants. All core samples recovered for this study contain a thin dark layer at the structural concrete surfaces consistent with the application of a penetrative sealant. Debondings present at probes B1 and 2E between epoxy membrane and Conflow display a superficially similar appearing residue. While no chemical analysis has been performed on these other samples, it appears that a penetrative sealant may have been applied to many surfaces within the application. It is not known to what extent such a sealant (if present) is compatible with the flexible epoxy membrane. Once again, questions related to specific material compatibility should be directly addressed to the manufacturer.

Core #1 reflects the only sample fully recovering the occurrence of terrazzo directly overlying structural concrete. While no debonding is detected along the entire corridor from which this sample was recovered, it is notable that a concrete delamination is present within the core sample. The delamination occurs cleanly between the main body of air-entrained normal weight concrete and a veneer of mortar from which the air-entrainment has been worked out during the finishing process. This structure is very typical of overfinishing of concrete during placement and often results in scaling or delamination. No scarification was detected in the core sample. However, scarification of the concrete at probes 1G and 1N was performed at a location within tens of feet of the core #1 location. Admittedly speculative, it may be possible that a similar overfinishing is present at these probes and the scarification penetrated an incipient delamination. The scarification would thereby expose an inherent weakness in the concrete leading to a debonding condition. If an incompatible sealant were also present, the combination of unbonded mortar and poorly bonded epoxy membrane could easily lead to a debonding failure.

The only remaining debonding involving concrete is located at probe #12. Here, the lower lift of unsanded Conflow has cleanly separated from the underlying concrete substrate. In fact, the separation continues cleanly across the concrete control joint without any adherence of Conflow.

Here it is believed that issues related to the Conflow mixture (discussed above) are responsible for the debonding.

Comments on Repairs

Based on the data provided by this report it cannot be confidently stated that the observed failure will not continue to worsen. Clearly there are potential weaknesses within the application not the least of which may reside below the base of the terrazzo system. The contacts between multiple lifts of Conflow may be the most questionable. In a high traffic area, horizontal weaknesses may be exacerbated even if "settlement stresses" related to initial differential volume changes have ceased to be a considerable factor. It is beyond the scope of this project to suggest possible reparations and Testwell Laboratories, Inc. does not assume responsibility for the success or failure of any attempts to salvage the existing flooring system nor does it favor any particular solution. However, the author simply stresses the need to carefully assess the results of any such attempts. Only one well exposed attempt at an epoxy injection reparation was observed at probe #12. It is clear that the failure of this repair had nothing to do with the inability of the terrazzo system to "rebond" with the Conflow substrate. In fact, the injection repair completely bypassed the terrazzo debonding and penetrated the separation between the lowest lift of Conflow and the structural concrete substrate. The structure exposed by the probe suggests that this repair actually tightly "rebonded" these two layers together. The greatest difficulty inherent in this method is the identification of multiple debondings that may be present in the subsurface. It is suggested that data provided by these studies be assessed by a party experienced in such repairs in order to determine whether or not a more "non-destructive" repair may be viable.

TESTWELL LABORATORIES, INC.

John J. Walsh, M.A.
Petrographer

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CORE DRILLING REPORT

CLIENT: TDX Construction Corporation
PROJECT: Baruch College – Site B
55 Lexington Avenue, New York, NY.
SAMPLES: Terrazzo cores
SAMPLE LOCATION: 1st Floor slab and 2nd Floor slab
DRILLED BY: TLI (G Ramkaran)
PICKED UP BY: TLI (G Ramkaran)

REPORT#: ML-03/NBX-004
PROJECT#: NBX-004AA
DATE DRILLED: 3/21/03
REPORT DATE: 3/31/03

Page 1 of 1

Table 1: Details of cores drilled.

Core Number	1	2	3
Core Location	1st Floor	2nd Floor	2nd Floor
Length Drilled, In.	3.5	3.5	3.5
Length Recovered, In.	3.25	3.25	2.75
Diameter, D, In.	3.0	3.0	3.0

Note: Three terrazzo cores were drilled for the purpose of Petrographic examination. Testing is in progress and results will be reported as soon as possible.

TESTWELL LABORATORIES, INC.

Kaspal R. Thummo, Eng.Sc.D. P.E.
Vice President / Lab Director
KRT/SK

Appendix I: Photographs and Photomicrographs

Microscopic examination was performed on an Olympus BX-51 polarized/reflected light microscope and a Bausch and Lomb Stereozoom 7 stereoscopic reflected light microscope. Both microscopes are fitted with an Olympus DP-11 digital camera. The camera is also fitted with lens attachments for macroscopic photography. The overlays presented in the photomicrographs (e.g., text, scale bars, and arrows) are prepared as layers in Adobe Photoshop 6.0 and converted to the jpeg format. Digital processing is limited to those functions normally performed during standard print photography processing. Photographs intended to be visually compared are taken under the same exposure conditions whenever possible.

The following abbreviations may be found in the figure captions and overlays and are defined as follows:

cm	centimeters
mm	millimeters
µm	microns (1 micron = 1/1000 millimeter)
PPL	Plane polarized light
XPL	Crossed polarized light

AV	Air void
CA	Coarse aggregate
CH	Calcium hydroxide
FA	Fine aggregate
HCP	Hydrated cement paste
M	Mortar
UCP	Unhydrated cement particle

Concrete images viewed microscopically may often be confusing and non-intuitive to those not accustomed to the techniques employed. The following is offered as a brief explanation of the various views encountered in order that the reader may gain a better appreciation of what is being described.

Reflected light images: These are simply magnified images of the concrete surface as would be observed by the human eye. A variety of surface preparations may be employed including polished and fractured surfaces. The reader should make careful note of the included scale bars as minor deficiencies may seem much more significant when magnified.

Plane polarized light images: This imaging technique is most often employed in order to discern textural relationships and microstructure. To employ this technique, concrete samples are milled so thinly (anywhere from 20 to 30 microns depending on the purpose) so as to allow light to be transmitted through the material. In many cases, TLI also employs a technique whereby the material is impregnated with a low viscosity, blue-dyed epoxy. Anything appearing blue therefore represents some type of void space (e.g.; air voids, capillary pores, open cracks, etc.) Hydrated cement paste typically appears a light shade of brown in this view (with a blue hue when impregnated with the above-mentioned epoxy). With some exceptions, most aggregate materials are very light colored if not altogether white. Some particles will appear to stand out in higher relief than others. This is solely a function of the various refractive indices of different materials with respect to the mounting epoxy. It is not unlike the way an ice cube will appear be more "visible" in air than in a glass of water.

Crossed polarized light images: This imaging technique is most often employed in order to distinguish between various micro-components or highlight the textural relationships between certain components not easily distinguished in plane polarized light. Using the same thin sections, this technique places the sample between two pieces of polarizing film at right angles to each other in order to determine the crystal structure of the materials under consideration. Isotropic materials (e.g.; hydrated cement paste, pozzolans and other glasses, many oxides, etc.) will not transmit light under crossed polars and therefore appear black. Non-isotropic crystals (e.g.; residual cement, calcium hydroxide, calcium carbonate, and most aggregate minerals) will appear colored. The colors are a function of the thickness, crystal structure, and orientation of the mineral. Many minerals will exhibit a range of colors based on their orientation. For example, quartz sand in the aggregate will appear black to white and every shade of gray in between. Difference in color does not necessarily indicate a difference in material type. When no other prompt is given in the figure caption, the reader should appeal to general shapes and morphological characteristics when identifying the components being illustrated.

Chemical treatments: Many chemical techniques (etches and stains typically) are used to isolate and enhance a variety of conditions within concrete and stone material. These techniques will often produce strongly colored images. The reader is cautioned to carefully read the captions in order to understand the extent of the condition being exhibited.

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REPORT OF FOURIER TRANSFORM INFRARED SPECTROSCOPIC ANALYSIS OF EPOXY MEMBRANE SURFACE

Client:	TDX Construction Corp.	**Lab #:**	NBX-004AA
Project:	Baruch College - Site B	**Report #:**	ML-02/NBX-004
Address:	55 Lexington Avenue New York, New York	**Date Received:** **Report Date:**	03/04/03 03/25/03
Specimen Type:	Flexible epoxy membrane on concrete slab	**Petrographer:**	J. Walsh
Sampled by:	Client		
Delivered by:	TLI	**Page 1 of 5**	

INTRODUCTION

At the request of Tom Spinthourakis of TDX Construction Corporation, a site visit was made at Baruch College, New Campus Site B at 25th Street and Lexington Avenue, New York on March 4, 2003. The purpose of the visit was to investigate a debonding condition evident in an epoxy-based, cast in place terrazzo flooring system. TDX Construction had previously removed seven probes throughout the building by sawcutting debonded portions of the system past the failed sections and removing solid samples. Six specimens were returned to Testwell Laboratories for further analysis. Two of the samples from the ground floor represented the epoxy-based terrazzo system directly overlying scarified concrete slab. Indications of a residue at the base of the flexible epoxy membrane suggested preliminary testing for the presence of contaminants between the concrete slab and the epoxy membrane. Analysis was performed by Fourier Transform Infrared Spectroscopy (FTIR) using Attenuated Total Reflectance (ATR) Spectroscopy for non-volatile (NV) organic surface composition.

LABORATORY FINDINGS

The flexible epoxy membrane is light gray in color with a matte plastic luster when freshly cut. The base of the membrane at the debonding site for the samples overlying scarified concrete does not have this appearance. Instead, there is a residue of flaked concrete where the epoxy membrane filled the scarified grooves. Along the flat portions overlying unscarred concrete, the base of the membrane is a darker greenish gray and has a resinous luster suggesting some sort of residue present between the membrane and the concrete. FTIR analysis was performed on a portion of freshly exposed epoxy membrane (as a control) as well as along the darker residue.

The spectrum for the control sample is consistent with a typical epoxy material. The spectrum for the residue contains an extra signal identified as a styrene acrylate. Styrene acrylate is one of the principal ingredients of most concrete sealants. It is likely that a sealant was applied to the concrete slab prior to placement of the terrazzo system.

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Samples will be discarded after three months unless otherwise instructed. This report is the confidential property of the client and any unauthorized reproduction is strictly prohibited. The interpretations and conclusions presented in this report are based on the samples provided.

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PRELIMINARY SITE INVESTIGATION REPORT

Client:	TDX Construction Corp.	**Lab #:**	NBX-004AA
Project:	Baruch College - Site B	**Report #:**	ML-01/NBX-004
Address:	55 Lexington Avenue New York, New York	**Field Visit Date:**	03/04/03
		Report Date:	03/05/03
Construction Type:	Terrazzo flooring system on concrete slab	**Petrographer:**	J. Walsh
		Page 1 of 10	

1. INTRODUCTION

At the request of Tom Spinthourakis of TDX Construction Corporation, a site visit was made at Baruch College, New Campus Site B at 25th Street and Lexington Avenue, New York on March 4, 2003. The purpose of the visit was to investigate a debonding condition evident in an epoxy-based, cast in place terrazzo flooring system. TDX Construction had previously removed seven probes throughout the building by sawcutting debonded portions of the system past the failed sections and removing solid samples. The probes were carefully covered with pressboard and sealed with duct tape. Probes were identified by TDX Construction according to floor level (B1, 1G, 1N, 2W, 2E, 7, and 12). Probe locations are filed with TDX Construction. The samples were labeled and stored in the onsite Facilities Office in an organized manner.

The site visit included the following components:

1) A 2.5 hour walk-through of the probe locations where all probes were exposed and studied. The immediate vicinity of each location was also examined in a cursory manner to assess the magnitude of the condition.
2) A briefing with TDX project management to discuss preliminary findings and possible analyses.
3) A perusal with Tom Spinthourakis of relevant job specifications and materials specification sheets.
4) A subsampling of six of the seven probe locations to collect representatives of all conditions observed in the field. Subsampling was agreed to between the author and Tom Spinthourakis.
5) Identification of four coring locations for future sampling. The samples will be held for petrographic analysis if such analysis is requested by TDX Construction.

2. PLACEMENT HISTORY

According to Tom Spinthourakis, all construction at the site is relatively recent. The concrete slabs on which the terrazzo system was placed were cured in excess of 28 days before the flooring was installed. The terrazzo system was installed approximately one year ago under closed construction conditions with climate control already in place. The substrate was scarified or treated with one or more layers of self-leveling flooring (Conflow by Conspeci when required. No other pretreatments were clearly recalled. The substrate was coated by a roll-on epoxy membrane (FlexGuard by TEC). A gridwork of adhesive was placed on which zinc strips were adhered. The terrazzo system (Tuff-Lite 5 by TEC) was field mixed and placed. After curing of the epoxy matrix, the terrazzo was ground and polished using diamond pad. The final finish was described as smooth with no small-scale imperfections. Some typical larger scale undulations were noted. The debonding condition was observed soon after and was defined by a curling of the terrazzo segments at the zinc strips.

3. FIELD OBSERVATIONS

The following observations were made by the author during the jobsite walk-through:

1) The placement history is suggested by observed field relationships. A lightweight slab on deck was placed. A surface consistent with a trowel finish is detected (i.e.; a smooth surface containing all cream and no raised fine aggregate). In some locations (1G and 1N) a deep scarification of the hardened slab was performed. In others (2E), some fine scouring is evident. In other locations (B1, 2W, 7, and 12) one or more layers of self-leveling compound were placed over the structural slab. A thin layer of gray epoxy membrane was placed. Zinc strip adhesive was placed before the epoxy membrane solidified. This is indicated by the indentation of the membrane by the adhesive (most clearly detected at probes 2E and 12). The zinc strips were embedded while the adhesive was uncured (also indicated by indentation). It would appear that the membrane, adhesive, and strips were all installed in quick succession as a single procedure as no other disruption of the membrane is detected. The terrazzo system was placed after all other components were hardened (not necessarily cured) and well compacted against the zinc strips. The hardened terrazzo system was ground and polished.
2) Most terrazzo segments are 2 x 4 feet in plan separated by zinc strips. The pattern varies in more open areas.
3) All debondings may be described as convex curlings of individual terrazzo segments. The greatest separation and deflection occurs at corners. Central edges are usually well adhered and segment centers are always adhered. No complete debondings of entire terrazzo segments are observed (see also note 8 below).
4) Certain corridors and areas display greater failure than others. In some places, the debonding condition is not apparent. Some degree of failure is observed at every floor level examined.
5) No obvious structural pattern of debonding is evident. That is to say that the failure does not tend to occur in the vicinity of doorways or in the center of a corridor for example. The occurrences are essentially random.
6) At each probe, the failure occurs between the epoxy membrane and the substrate. The debonding occurred cleanly without pulling out any portion of the substrate and rarely leaving any residue of the membrane behind. This condition exists whether the substrate is concrete slab or self-leveling flooring. It is also notable that no residue of the epoxy membrane is found within any negative relief areas of the substrate. Even where the

substrate is deeply scarified (1G and 1N), no relict of the epoxy membrane remains in the grooves.

7) Each of the recovered samples display some residual material at the lower surface of the epoxy membrane. Nowhere is the lower surface of the epoxy found to be "fresh".

8) Probe 2W exposes a section centered on a corner of four terrazzo segments. The original debonding (as opposed to that created by the sample removal) is clearly defined as a rounded cross. This indicates a regular ovate pattern of failure.

9) Some salt deposits are detected along the exposed substrate and these are always coincident with the zinc strip locations. These deposits clearly post-date placement and are probably related to the drying of cleaning solutions after separation of the terrazzo with the zinc strips occurred and fluid access to the substrate was permitted.

10) No other horizontal failures are noted in the terrazzo system. The zinc strip adhesive is well adhered to the epoxy membrane as well as the L-shaped zinc strips. Horizontal contacts between the terrazzo system and the zinc strips are all intact. No failures are detected between the epoxy membrane and the terrazzo system.

11) Some indication of failure between the slab and self-leveling flooring bond is noted. This is evidenced by clean separations at probe locations 7 and 12. Probe B-1 exposes a four corner contact. Sounding of the substrate revealed a debonding of the Conflow only below one corner of the four terrazzo segments. Samples of the debonded Conflow were recovered freshly from the substrate.

12) No significant vertically oriented fractures are detected in the main body of the terrazzo. Only one location was identified near the 25th Street entrance on the ground floor. The crack is perpendicular to the construction and was suggested by Tom Spinthourakis to be related to an underlying slab crack. The form of the crack is consistent with that interpretation. Other finer scale vertical cracking is rare and is associated with the "alligator texture" discussed below.

13) Other vertical cracking is strictly related to the clean separation of the terrazzo from the zinc strips. This is not considered a failure as the zinc grid is likely designed as a control joint system. Separations are detected even where debonding is not present. The separations are of hairline thickness unless curling of the terrazzo has occurred. It is noted that separation occurs on one side of the zinc strip. In some cases, the separation switches sides with a small overlap. This is consistent with horizontally oriented tensile stress release from separations propagating on either side of the strip. No "double-sided" separations are detected. The separations propagate vertically through the lower epoxy membrane.

14) A possibly unrelated condition is informally described as "alligator texture" and was pointed out by Tom Spinthourakis. The texture is observed more or less at all locations and is defined by a differential surface relief between the aggregate (in high relief) and the epoxy matrix (in low relief). The texture usually occurs at terrazzo segment edges but often juts into the main body of the terrazzo in a curving manner. At first, it was thought there might be a correlation between lower abundances of aggregate and the alligator texture but this correlation was not borne out by further site examination. In fact, it is sometimes observed where there is a locally high concentration of aggregate grains. According to TDX, the texture did not exist immediately following the finishing operation.

4. PRELIMINARY CONCLUSIONS

The scale of the failure is confined to within terrazzo segments and exhibits no coherent relationship to underlying structural units. Therefore, it is believed that the cause of the problem is limited to the flooring application and not larger scale movements or failures of the underlying structural slab. The morphology of the failure tends to be defined by a convex curling and an ovate pattern of debonding. This is consistent with deformation related to material shrinkage and this shrinkage is believed to be the primary *stress* leading to the debonding. However, shrinkage is supposed to be accommodated by failure along the zinc joints and it should be stressed that no suggestion is being made here that shrinkage was *necessarily* excessive. The debonding occurs strictly between the epoxy membrane and the substrate regardless of whether the substrate is lightweight concrete or self-leveling compound. Furthermore, the debonding is usually complete with no residual epoxy membrane adherent to the substrate even where scarified. Clearly, the epoxy-substrate bond is the weakest in the system. This weak bond appears to be exploited by the natural material shrinkage.

There appears to be some evidence of residues below the epoxy membrane and this is an area for further investigation. Incomplete cleaning of the substrate may be responsible for a weak epoxy bond. This seems likely particularly where the concrete slab is scarified and the membrane has not even adhered to the rough grooves of the preparation. In terms of materials, there does not appear to be any deviations from the manufacturer's recommendations. It may be more difficult to determine whether or not a curing agent had been applied to the concrete.

The "alligator texture" may be related to shrinkage as the epoxy matrix is in lower relief relative to the aggregate. However, the distribution pattern is not very ordered and it may be difficult to relate this texture to shrinkage of the product.

5. SUGGESTIONS FOR FURTHER ANALYSES

A) Most laboratory analyses will not be able to assess the manufacturer's claims on material behavior. Empirical tests on fresh material would need to be performed. Results of such tests should be sought from the manufacturer as a first step.

B) A low power microscopic analysis of the field samples should be performed to investigate the nature of the lower epoxy surface. Some indications of contaminants or residues may be identified in such an analysis. Other bonding surfaces and microcracking may also be investigated.

C) Some "oily" looking residues were reported by Tom Spinthourakis and at least some suggestion of this is evident in the field samples as received. FTIR analysis can qualitatively identify the presence of organic functional groups and these can be compared to those reported in the MSDS sheets of the epoxy membrane. Any functional groups not belonging to the epoxy may be considered a contaminant.

D) A full petrographic analysis of fresh core samples may be desirable. Samples will be milled to 30 µm thickness in an intact condition and analysed under high power polarized transmitted light. The original undisturbed bonds can be assessed and any dust layers may be identified. Microscopic bonding of other components of the terrazzo system will be addressed as well as the nature and quality of the concrete substrate.

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